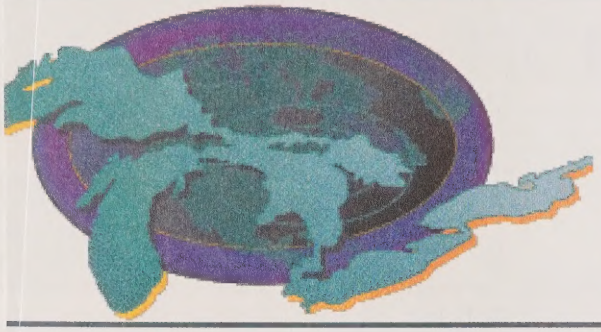


GREAT LAKES FACT SHEET

Contaminants in Water and Precipitation from the Canadian Great Lakes: 10 Years of Monitoring Levels

This fact sheet describes the spatial and temporal concentration patterns of 8 persistent toxic substances that historically have been reported to threaten or potentially threaten human health and aquatic life. Some, like dieldrin and lindane, are ubiquitous throughout the Great Lakes; others, such as mirex, hexachlorobenzene and octachlorostyrene, are more localized. Spatial concentration patterns reflect historical or on-going sources. Temporal patterns are influenced by historical or on-going sources but also reflect pollution prevention activities. This fact sheet also compares ambient concentrations to water quality objectives.

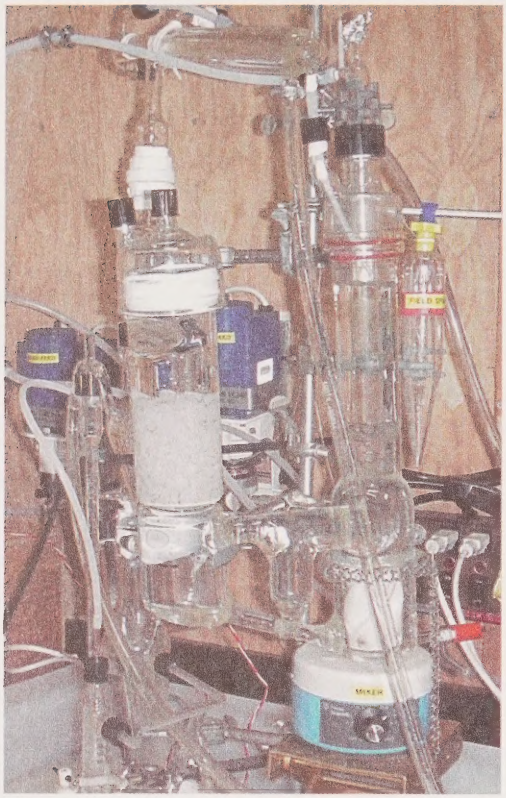
Introduction

Agricultural, industrial, and municipal activities both within and upwind of the basin have polluted the Great Lakes and degraded ecosystem health. A number of initiatives have focussed pollution prevention efforts on the various chemicals that continue to or potentially threaten human health and aquatic life. The most recent, the Great Lakes Binational Toxics Strategy, established a collaborative process by which all levels of government (federal, state and provincial), Environmental Organizations, the public, tribes, First Nations, and industry partners will work towards the goal of virtual elimination of persistent toxic substances.

Environment Canada conducts water quality surveillance and monitoring programs to fulfill commitments under the Great Lakes Water Quality Agreement which include ensuring compliance with water quality objectives, evaluating trends, and identifing emerging issues. The evaluation of trends can assess the effectiveness of pollution prevention activities such as those undertaken as a result of the Great Lakes Binational Toxics Strategy.

The CCGS Limnos - *used in the Open Lakes Surveillance*

Environment Canada Environnement Canada



Goulden Large Sample Extractor (GLSE)

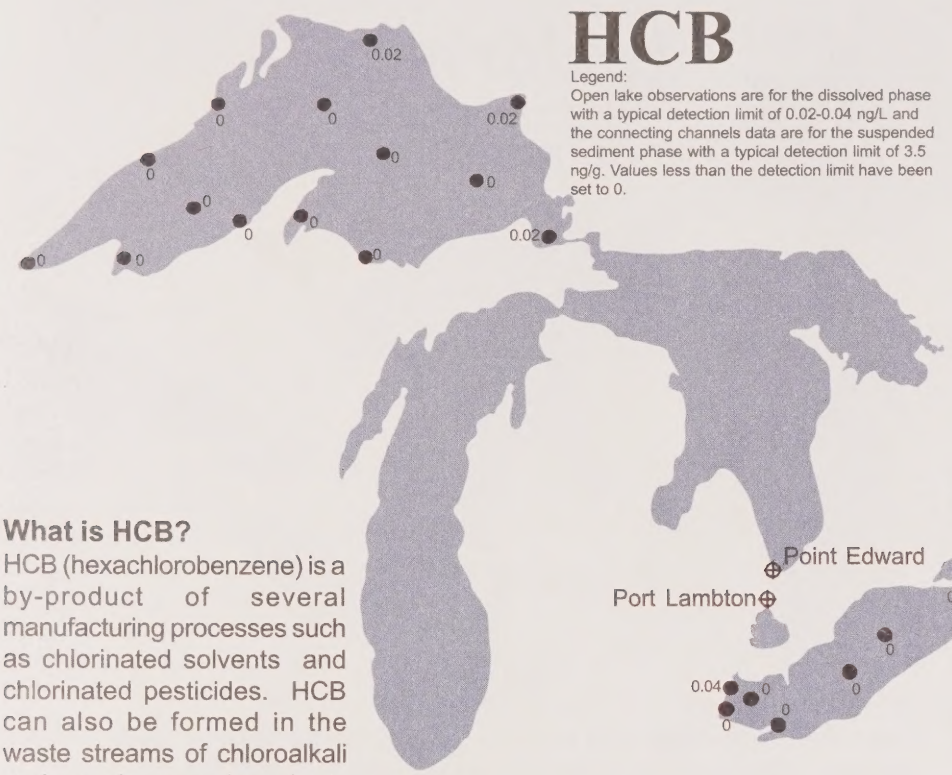
In 1986, monitoring and surveillance began in the lower connecting channels (St. Clair, Niagara and St. Lawrence Rivers) and in the open lakes to track inputs, outputs and in-lake concentrations of toxic chemicals.

The connecting channels' programs collect separate dissolved and suspended sediment samples using a continuous-flow centrifuge. To detect the low concentrations of contaminants, large volumes of water are required. Fifty to 100 litres are required for the dissolved phase and up to 10,000 litres in the suspended sediment phase. The contaminants in the dissolved phase are processed using a Goulden Large Sample Extractor (GLSE) which serves to concentrate the toxic chemicals into a solvent. Both the solvent and the suspended sediment phase are then analyzed for a range of chemicals. The whole water concentration can then be estimated by summing the concentrations in the two phases, taking into account the amount of suspended sediment in the water. Due to the low concentration of suspended sediment in the open waters of the lakes, only dissolved phase samples are analyzed.

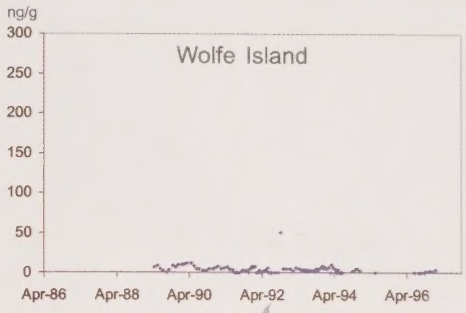
Beginning in 1983, Environment Canada established a network of precipitation stations throughout the Canadian side of the Great Lakes Basin to measure the deposition of toxic chemicals from the atmosphere to the lakes. The precipitation collectors work on the same principle as the Goulden Large Sample Extractor, collecting rain and snow and passing it through solvent in the field to concentrate the toxic chemicals. Once again the solvent is collected on a two week basis and analyzed.

MIC Sangamo Wet-only Precipitation Collector

HCB

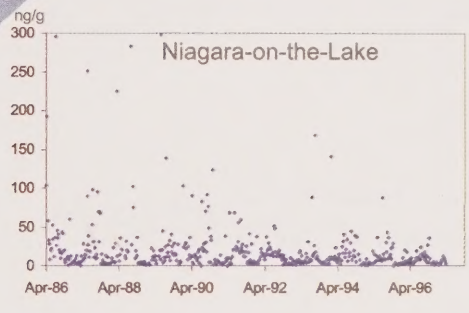


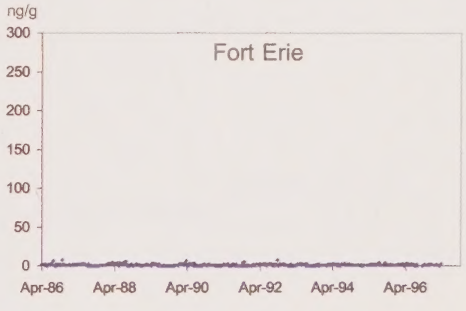
Legend:
Open lake observations are for the dissolved phase with a typical detection limit of 0.02-0.04 ng/L and the connecting channels data are for the suspended sediment phase with a typical detection limit of 3.5 ng/g. Values less than the detection limit have been set to 0.



What is HCB?

HCB (hexachlorobenzene) is a by-product of several manufacturing processes such as chlorinated solvents and chlorinated pesticides. HCB can also be formed in the waste streams of chloroalkali and wood-preserving plants and the burning of municipal waste. It was used as a registered fungicide in the '60s to protect the seeds of onions and sorghum, wheat and other grains until 1965. It was also used to make fireworks, ammunition and synthetic rubber. It is now used in the manufacture of pyrotechnics, aluminum and tracer bullets. In the '70s and '80s, it was found that the use of organochlorine pesticides played a significant role in eggshell thinning, reproductive failure and population declines in birds. These observations led to tighter restrictions on the use of HCB.





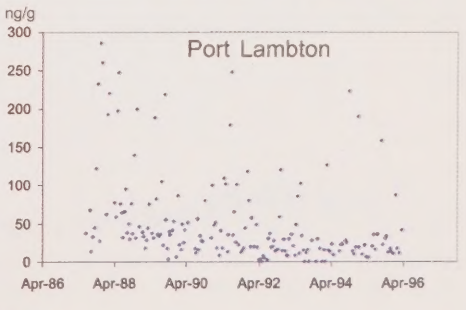
Measuring Progress

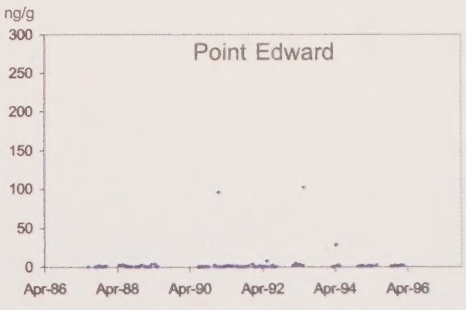
HCB was found intermittently at all precipitation sites, throughout the Basin in trace amounts.

Dissolved phase concentrations in Lake Ontario (1993) and Lake Erie (1995) were at or below the detection limit of 0.04 ng/L and, due to analytical improvements, 0.02 ng/L in Lake Superior (1997).

Since 1986, HCB was rarely detected in the suspended sediment phase at the upstream stations in the St. Clair and Niagara Rivers. However it was routinely detected in samples from the downstream stations indicating sources of HCB along the lengths of these two rivers. For example, the average whole water concentrations at Fort Erie and Niagara-on-the-Lake from 1990 to 1997 were 0.025 and 0.095 ng/L, respectively. At Niagara-on-the-Lake, the dissolved phase and suspended sediment phase each represented approximately 50% of the whole water concentration.

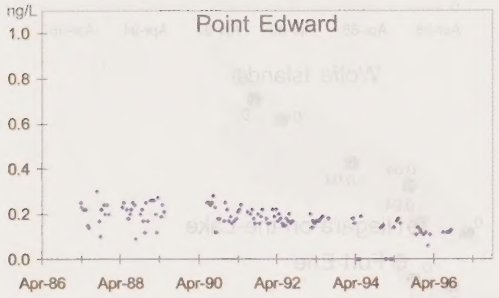
Concentrations have decreased over time. In 1986, the average concentration at Niagara-on-the-Lake was 0.23 ng/L whereas, recent yearly average concentrations were 0.07 ng/L. The most sensitive criterion of the various environmental agencies in the lower lakes is New York State's ambient water quality standard of 0.03 ng/L for the protection of human consumers of fish.

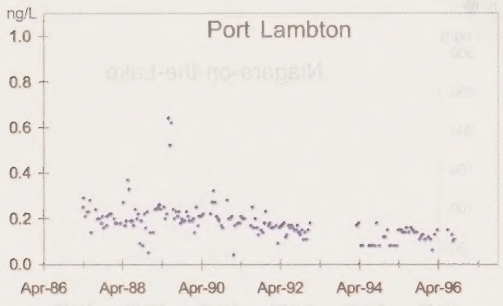


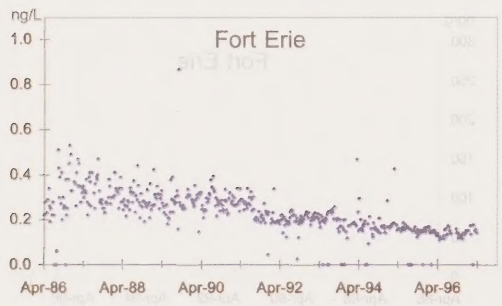


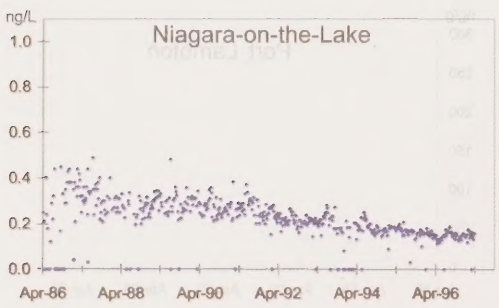
Dieldrin

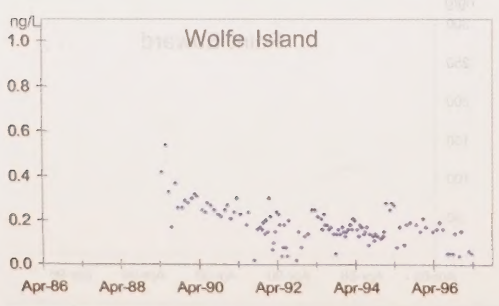
Legend:
Open lake and connecting channel observations are for the dissolved phase with a typical detection limit of 0.05 ng/L. Values less than the detection limit have been set to 0.

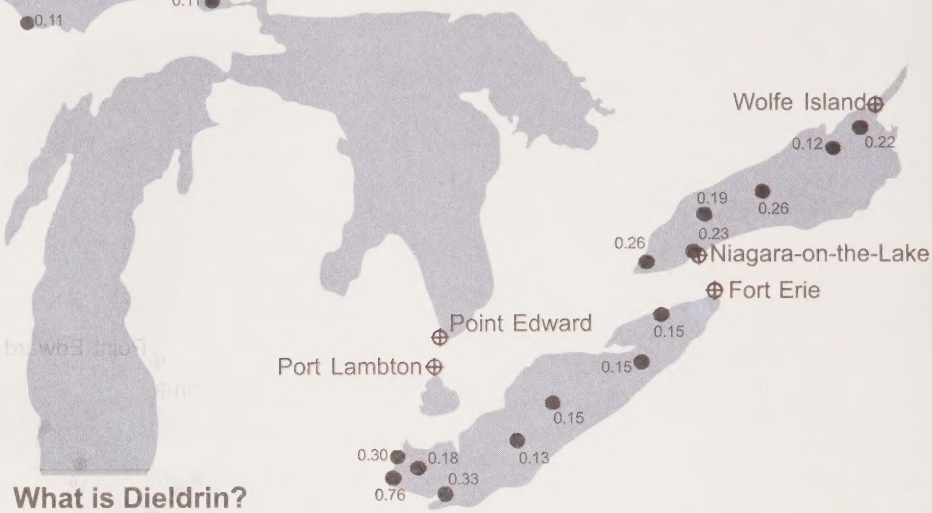








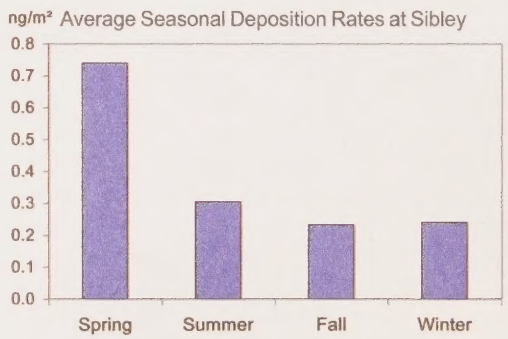




What is Dieldrin?

Dieldrin is an organochlorine pesticide that was developed after WWII. Dieldrin and the related pesticide aldrin were widely used to control soil insect pests on corn and cotton plants between 1950-1970. Non-agricultural uses included termite control and mothproofing of woolen garments. During the '60s, it was found that chronic exposure to organochlorine pesticide residues played a key role in eggshell thinning, reproductive failure and population declines in birds. These environmental and health concerns led to limiting the use of dieldrin in the '70s to termite control only. After 1985, no importation into Canada and US was reported. Registrations for both compounds were cancelled in Canada and the United States between 1989 and 1991.

Measuring Progress



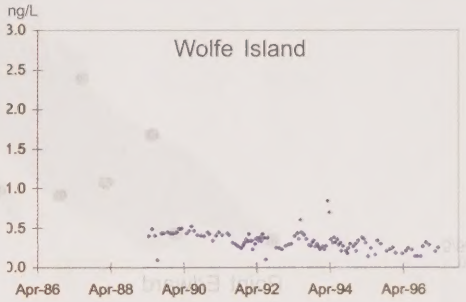
Dieldrin deposition in precipitation has a seasonal high typically occurring during the spring. Deposition rates have not decreased since 1986 (see page 11).

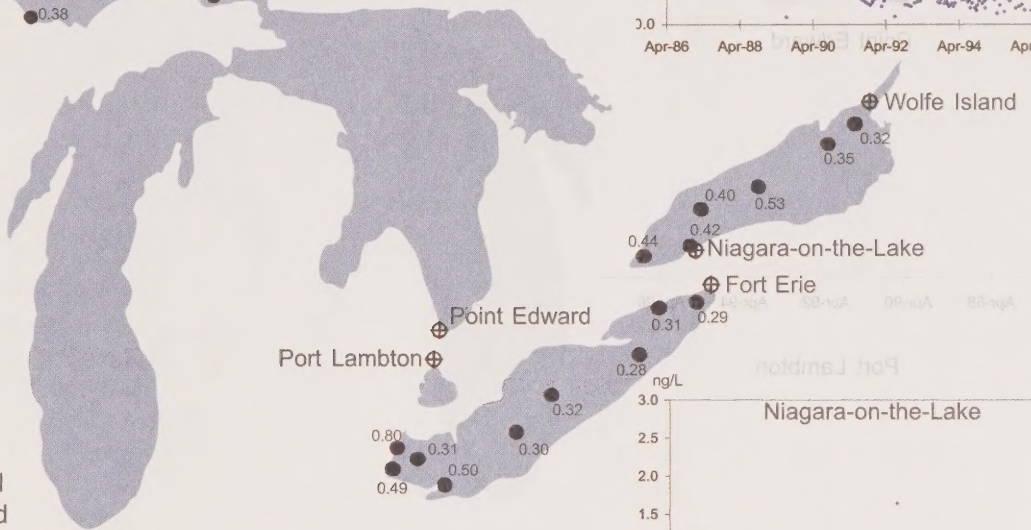
Lake Superior dissolved phase concentrations in 1997 ranged from 0.09 to 0.13 ng/L. Meanwhile, in Lake Erie, concentrations ranged from 0.13 to 0.76 ng/L in 1994. Lake Ontario concentrations were 0.12 to 0.26 ng/L in 1992. Some allowance for decreasing concentrations over time would have to be made when comparing Lake Superior to the two lower lakes, however, western Lake Erie has obviously elevated concentrations.

Since 1986, concentrations in the connecting channels have decreased over time and, in recent years, were similar. The dissolved phase typically accounted for over 90% of the whole water concentration. The average whole water concentration at Niagara-on-the-Lake in 1986/87 was 0.33 ng/L. In 96/97, the concentration had decreased to 0.16 ng/L. The most sensitive criterion of the various environmental agencies in the lower lakes is New York state's ambient water quality standard of 0.0006 ng/L for the protection of human consumers of fish. Current concentrations at Niagara-on-the-Lake exceeded the New York standard by 250 times.

Lindane

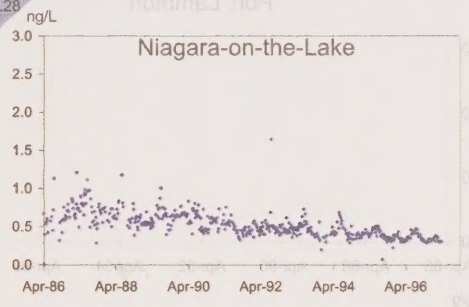
Legend:
Open lake and connecting channel observations are for the dissolved phase with a typical detection limit of 0.14 ng/L. Values less than the detection limit have been set to 0.





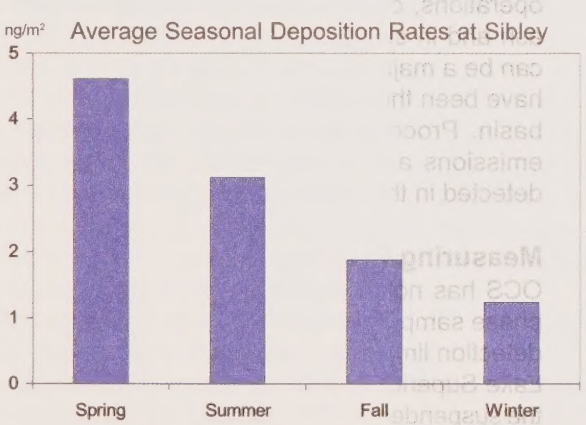
What is Lindane?

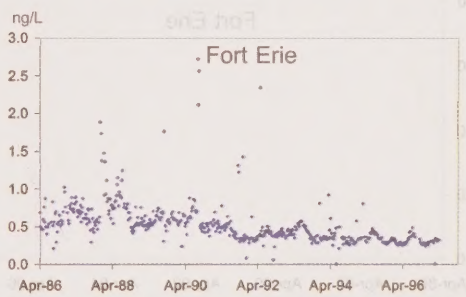
Lindane, an organochlorine insecticide, has been used since the 1940s. In Canada and the United States, lindane formulations have been used as an insecticide for seed treatment and pests on fruit, vegetables, turf, ornamentals, and in forestry. Lindane has also been used for pest treatment around buildings, and as a topical treatment for humans and animals. Lindane is no longer manufactured in the United States and Canada although imports account for approximately 250 tons per year which are used in the formulation of lindane products. Global Lindane usage has declined over the last 10-15 years. Lindane is persistent and bioaccumulative.

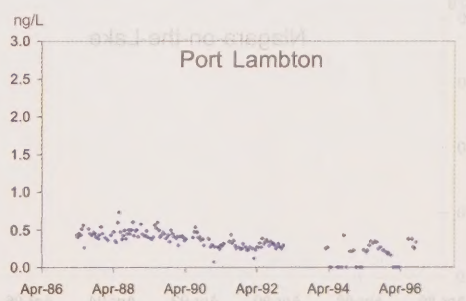


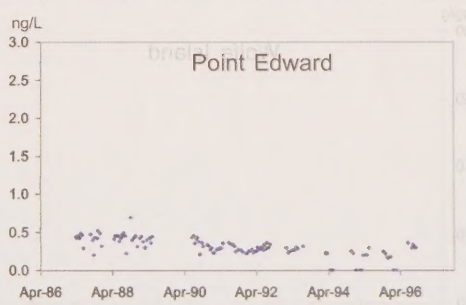
Measuring Progress

Lindane deposition from precipitation decreased from 1984 to 1990 but has not changed since 1990 (see page 11). Deposition rates were generally highest in the spring and summer. Open lake concentrations were generally similar throughout the Great Lakes suggesting the atmosphere as the pre-dominant source. Dissolved phase concentrations in Lake Superior in 1997 ranged from 0.29 to 0.45 ng/L. In Lake Erie in 1995 the concentrations ranged from 0.28 to 0.80 ng/L. Lake Ontario concentrations ranged from 0.32 to 0.53 ng/L in 1992. Local sources appear to impact one site in the western end of Lake Erie.



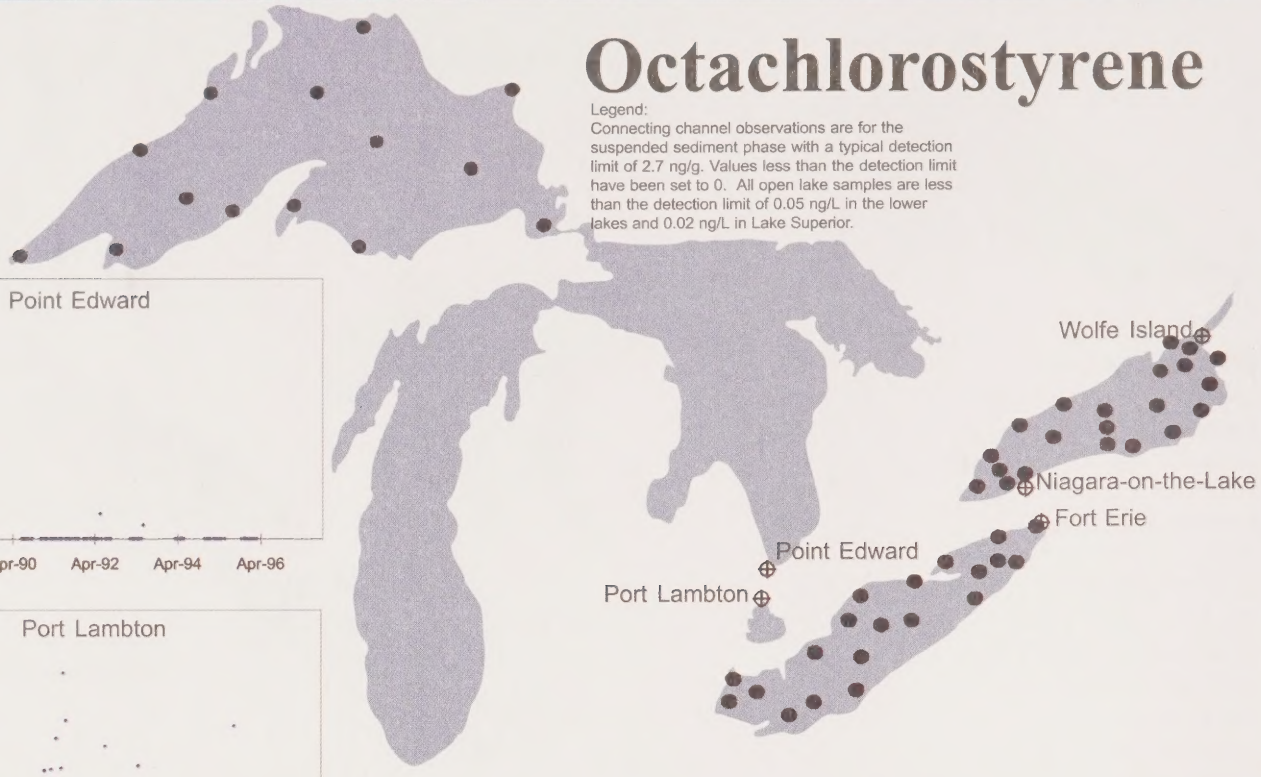


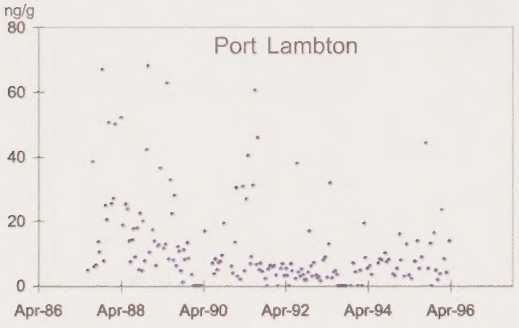


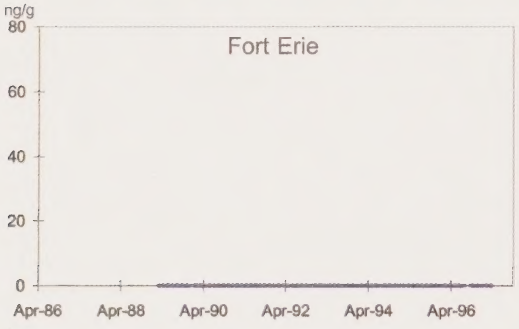


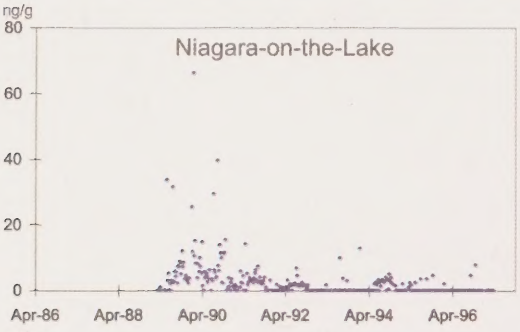
Since 1986, concentrations in the connecting channels have been decreasing over time. The dissolved phase typically accounts for more than 99% of the total whole water concentration. In 1986, the Lindane concentrations at Fort Erie and Niagara-on-the-Lake were 0.64 and 0.65 ng/L, respectively. By 1997, the concentrations had decreased to 0.32 and 0.35 ng/L, respectively. The most sensitive criterion of the various environmental agencies in the lower lakes is New York state's ambient water quality standard of 8 ng/L for the protection of human consumers of fish. Observed concentrations were one-tenth or less of this standard.

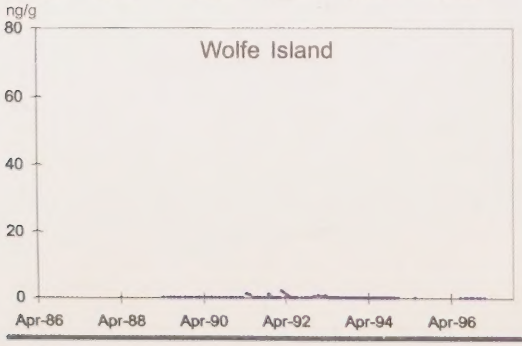
Octachlorostyrene











What is Octachlorostyrene?

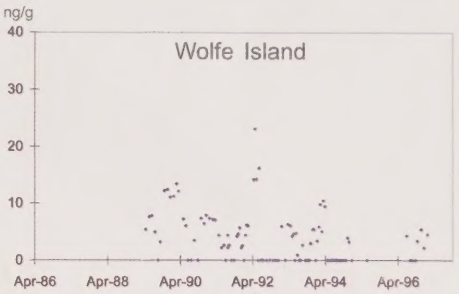
Octachlorostyrene (OCS) was an unwanted by-product of high temperature industrial processes that involve chlorine such as chlorine gas production, and metal production/finishing operations (eg., magnesium, tantalum, niobium). High temperature incineration of chlorinated hydrocarbons such as polyvinyl chloride (PVC) can also produce OCS. It has been found at aluminum smelting operations, coal fired cement kilns, in landfill leachate, in waste incinerator ash and in sludge from waste treatment facilities. Iron and steel production can be a major source of OCS. Past sources in the Great Lakes Basin would have been the numerous chlor-alkali plants which have been operated in the basin. Process modifications have resulted in a substantial decrease in emissions and environmental concentrations as a result. OCS has been detected in the water, sediment and fish tissues in the Great Lakes.

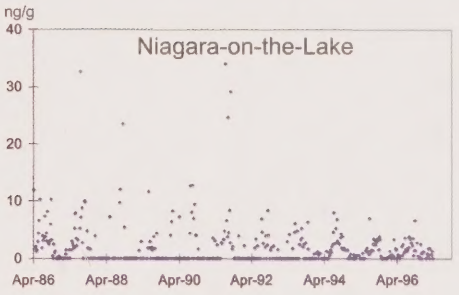
Measuring Progress

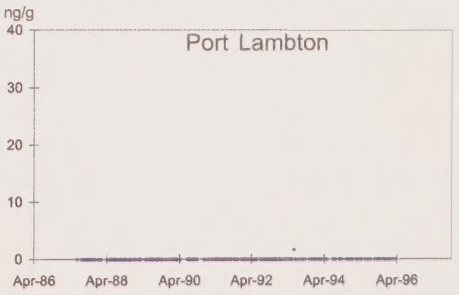
OCS has not been measured in precipitation. Concentrations in dissolved phase samples collected in 1998 and 1999 in the lower lakes were below the detection limit of 0.05 ng/L and, due to analytical improvements, 0.02 ng/L in Lake Superior in 1997. In the connecting channels, OCS is only observed in the suspended sediment phase. OCS was not detected at the upstream stations in the St. Clair or Niagara Rivers but is routinely detected in samples from the downstream stations suggesting that sources exist along these two rivers. Octachlorostyrene was not detected at Wolfe Island.

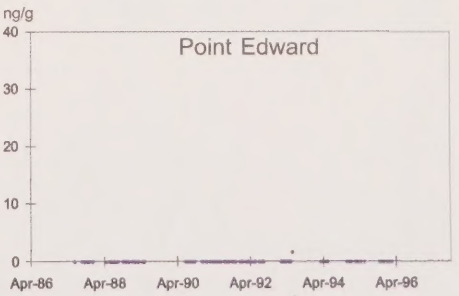
The average whole water concentration at Niagara-on-the-Lake has decreased more than 10-fold to 0.003 ng/L in recent years. The most sensitive criterion of the various environmental agencies in the lower lakes is New York State's ambient water quality standard of 0.006 ng/L for the protection of human consumers of fish. While the average concentration met the standard, at least 20% of the Niagara-on-the-Lake samples exceeded it from 1990 to 1997.

Mirex









What is Mirex?

From 1959 to 1972, Mirex was used to as a pesticide to control fire ants, and as a flame retardant in plastics, rubber, paint, paper and electrical goods. Mirex persists in the environment for years bound to sediment or soil particles and bioaccumulates in fish and other organisms. It has not been manufactured for use in the US since 1977 and has been banned under the Canadian Environmental Protection Act. Contamination in the Great Lakes is due to past use practices and from waste sites.

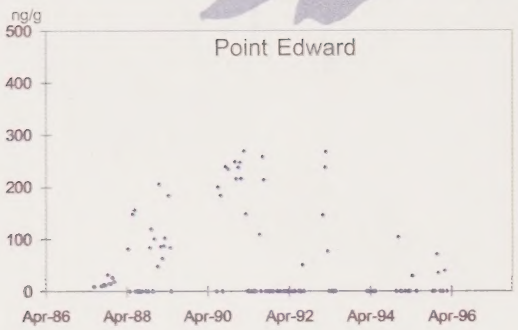
Measuring Progress

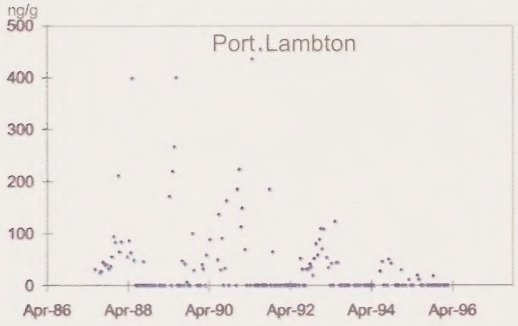
Mirex was not detected in precipitation. Mirex was only observed in the suspended sediment phase. Mirex was not detected in the St. Clair R. or at the upstream station in the Niagara River but was routinely detected at Niagara-on-the-Lake suggesting local sources exist along the length of the Niagara River. Inputs appear to be declining as concentrations have decreased by approximately 50%. Similarly, Mirex concentrations were also decreasing at Wolfe Island.

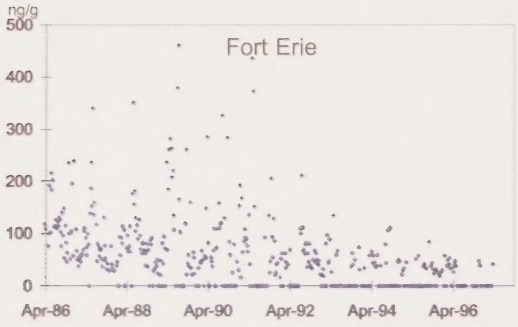
The average whole water concentration at Niagara-on-the-Lake has decreased from 0.014 ng/L to 0.006 ng/L from 1986 to 1997. The most sensitive criterion of the various environmental agencies in the lower lakes is New York State's ambient water quality standard of 0.001 ng/L for the protection of human consumers of fish.

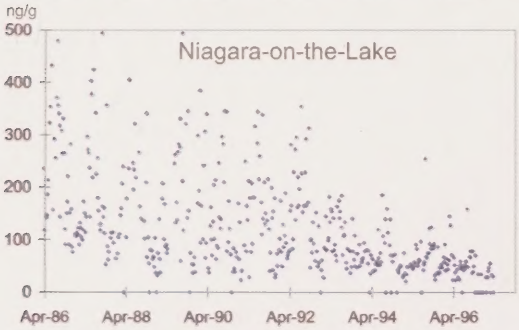
PCBs

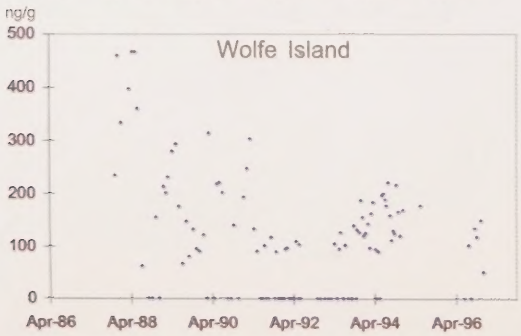
Legend:
Connecting channel observations are for the suspended sediment phase with a typical detection limit of 89 ng/g. Values less than the detection limit have been set to 0.











What are PCBs?

Since 1929, PCBs have been used in North America as: cooling and insulating fluids in transformers and capacitors; hydraulic fluids; surface coatings for carbonless copy paper; plasticizers in sealants, caulkings, synthetic resins, rubbers, paints, waxes and asphalts; as a flame retardant in lubricating oils; pesticide extenders; and in printing inks and adhesives. By 1971, the manufacturer recognized the environmental problems which had developed because of PCBs and initiated a program to phase out sales for open-ended uses, finally limiting sales to uses in electrical capacitors and transformers. The US production was terminated by 1977, and legislation banning PCBs became effective in 1979. As of 1977 in Canada, PCBs were only allowed in existing closed-system electrical and hydraulic systems and are to be replaced at the end of their service life. PCBs are widely dispersed in the environment, very persistent and accumulate dramatically in the food chain. They are linked to health problems, such as embryo mortality and deformities in wildlife, and are suspected of causing developmental problems in human infants.

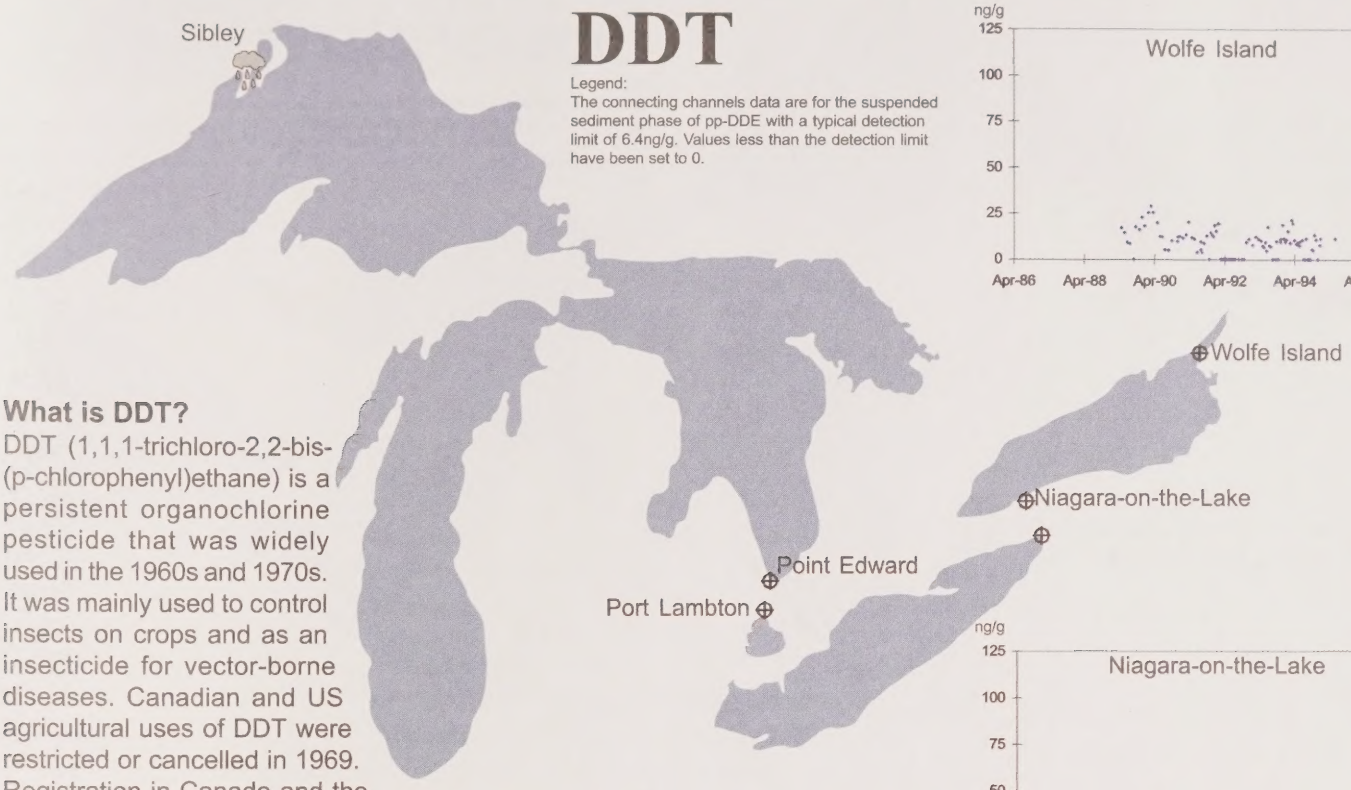
Measuring Progress

In the connecting channels, concentrations of PCBs in the suspended sediment phase have been decreasing over time. For example, at Niagara-on-the-Lake and Fort Erie, concentrations have declined from 1986 to 1996.

At Fort Erie and Niagara-on-the-Lake, the average whole water concentrations have decreased from approximately 2.9 to 0.8 ng/L from 1986 to 1997. The average whole water concentrations at Fort Erie and Niagara-on-the-Lake from 1990 to 1997 were 1.3 and 1.4 ng/L, respectively. The most sensitive criterion of the various environmental agencies in the lower lakes is New York State's ambient water quality standard of 0.001 ng/L for the protection of human consumers of fish. PCBs exceeded the New York standard in 100% of the samples from both Niagara River sites.

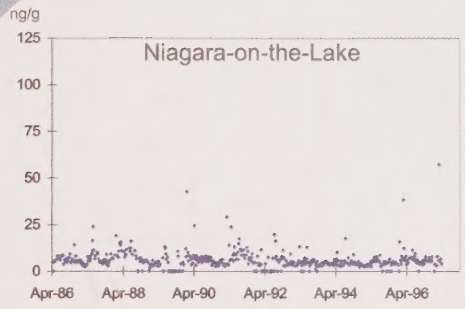
DDT

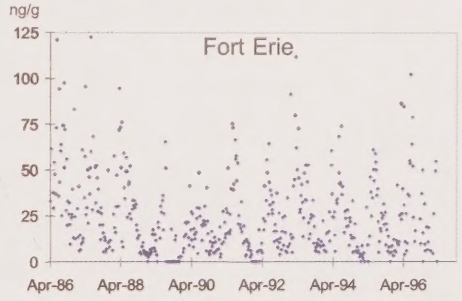
Legend:
The connecting channels data are for the suspended sediment phase of pp-DDE with a typical detection limit of 6.4ng/g. Values less than the detection limit have been set to 0.



What is DDT?

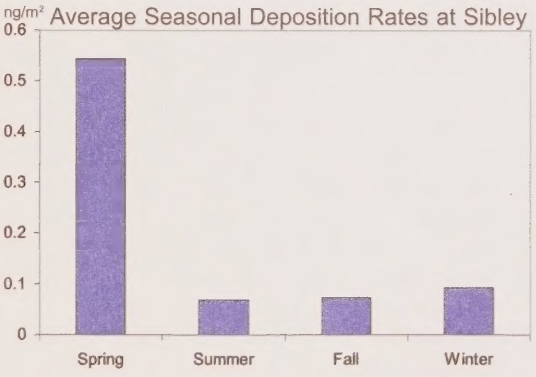
DDT (1,1,1-trichloro-2,2-bis-(p-chlorophenyl)ethane) is a persistent organochlorine pesticide that was widely used in the 1960s and 1970s. It was mainly used to control insects on crops and as an insecticide for vector-borne diseases. Canadian and US agricultural uses of DDT were restricted or cancelled in 1969. Registration in Canada and the US for all uses was cancelled between 1985 and 1989. Technical DDT also has the contaminants DDD and DDE. DDT, DDD and DDE have been linked to the decrease in the reproductive capabilities of fish and birds. Bird species affected included the bald eagle, brown pelican and osprey. DDT builds up in the fatty tissues of birds and fish. DDT is also highly toxic to aquatic organisms.





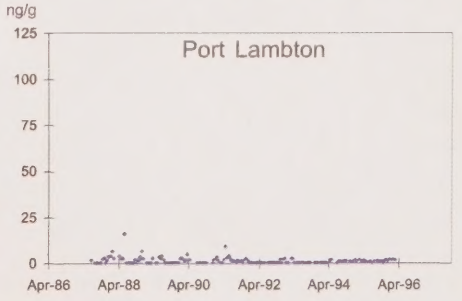
Measuring Progress

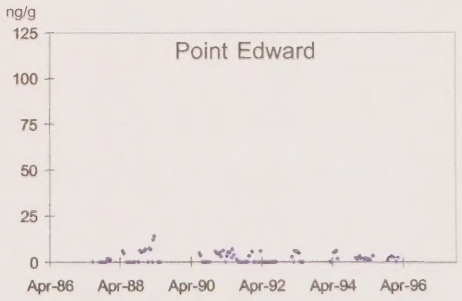
Depostion of p,p'-DDE in precipitation has a seasonal high, typically occurring during the spring. Deposition rates have not decreased since 1986 (see page 11).



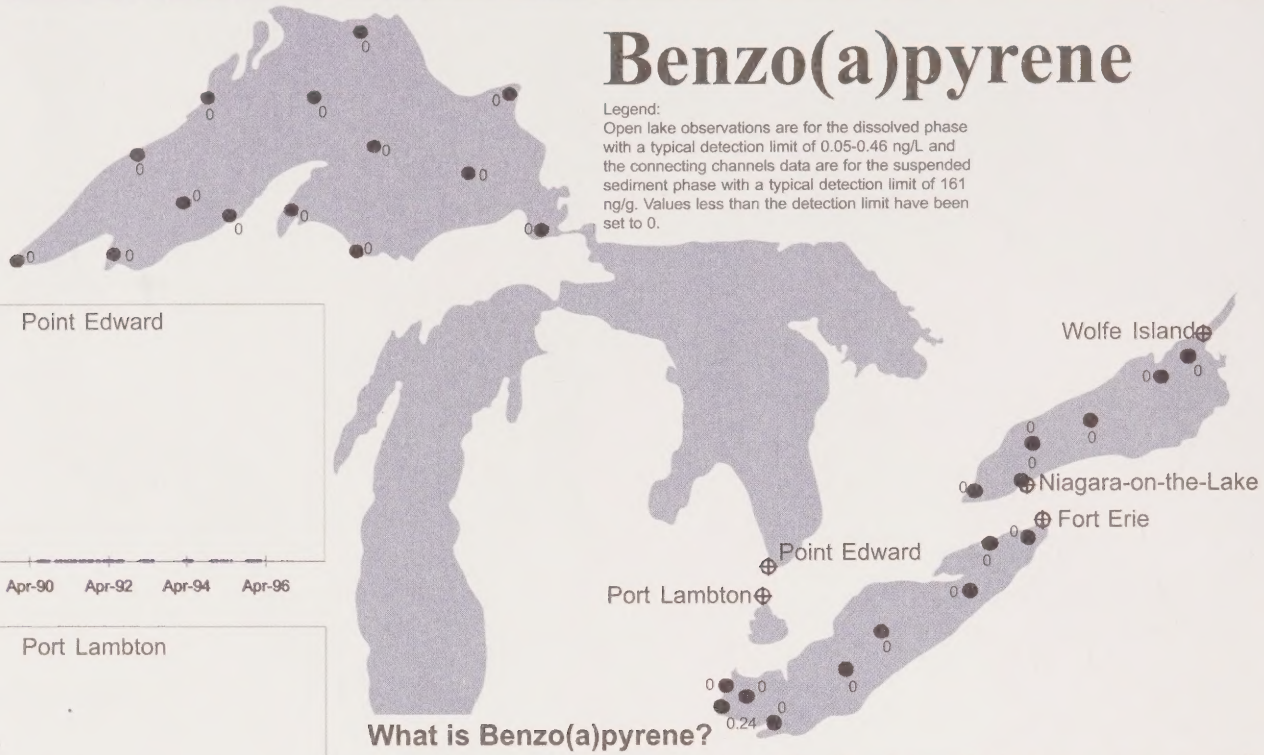
In 1992, concentrations in Lake Ontario were less than the detection limit of 0.08 ng/L. DDT and its metabolites are observed more frequently in the Niagara River than the St. Clair River presumably due to inputs from contaminated soils in the Lake Erie basin. Local contamination at the Fort Erie station is evident.

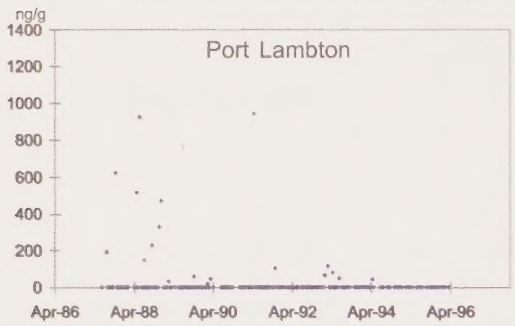
The suspended sediment phase accounts for the majority of the total concentration in the Niagara River. p,p'-DDE was the most commonly observed metabolite. The average whole water concentration of p,p'-DDE at Niagara-on-the-Lake from 1990 to 1997 was 0.06 ng/L. The most sensitive criterion of the various agencies in the lower lakes is New York state's ambient water quality standard of 0.007 ng/L p,p'-DDE for the protection of human consumers of fish. The standard was exceeded in at least 80% of the Niagara-on-the-Lake samples. Ohio has a wildlife protection criteria for DDT and metabolites of 0.011 ng/L. The yearly average total DDT concentration at Niagara-on-the-Lake since 1992 has been between 0.14 and 0.19 ng/L compared to 0.25 ng/L in 1986.

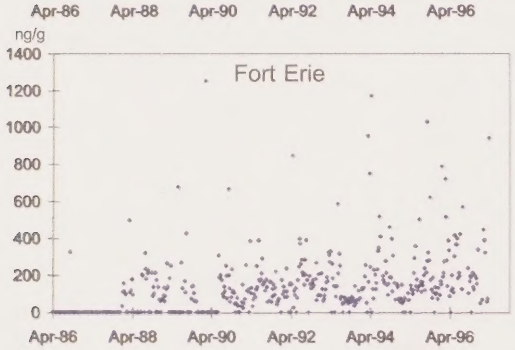


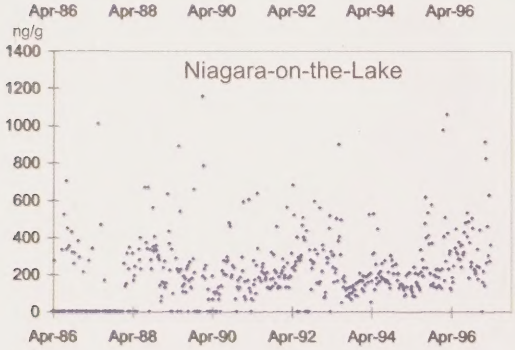


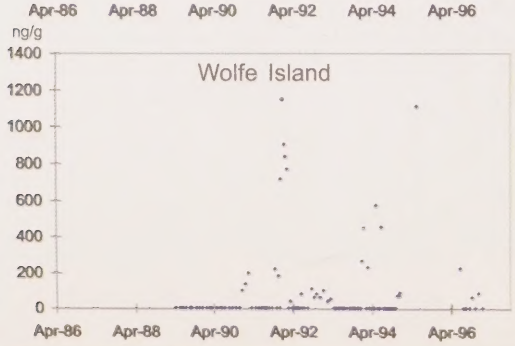
Benzo(a)pyrene











What is Benzo(a)pyrene?

Benzo(a)pyrene belongs to a large family of chemicals known as polycyclic aromatic hydrocarbons (PAHs). PAHs are formed during the incomplete burning of coal, oil and gas, garbage and other organic substances. Benzo(a)pyrene sources include pesticide manufacturing and application, chlorinated solvent manufacturing, iron/steel mills which use coke ovens, mobile source emissions, and home wood burning applications such as wood stoves. Benzo(a)pyrene escapes into the environment via industrial effluents, spills and leakage from landfill sites and storage tanks. It also enters the environment through the burning of motor fuels and incomplete combustion of refuse in municipal incinerators.

Measuring Progress

Open lake concentrations in the dissolved phase are generally below the detection limit in all lakes. In Lake Superior, concentrations were below the detection limit of 0.05 ng/L in 1996. In Lake Erie, 1995 concentrations were below the detection limit of 0.24 ng/L at all sites except one in the western end of the lake. In 1993, Lake Ontario concentrations were less than the detection limit of 0.46 ng/L at all sites. Benzo(a)pyrene has been infrequently detected in the St. Clair River and at Wolfe Island. In contrast, the chemical was consistently detected in the suspended sediment phase in the Niagara River with concentrations higher downstream. This suggests there were sources both upstream of the Niagara River and along the River. Concentrations in the suspended sediment phase at Fort Erie increased 135%.

The suspended sediment phase typically accounted for over 80% of the total concentration. The average whole water concentrations at Fort Erie and Niagara-on-the-Lake from 1990 to 1997 were 0.7 and 1.3 ng/L, respectively. The most sensitive criterion of the various environmental agencies in the lower lakes is New York State's ambient water quality standard of 1.2 ng/L for the protection of human consumers of fish. This standard was exceeded in at least 10% and 30% of the samples over the same time period at Fort Erie and Niagara-on-the-Lake, respectively.

Summary:

Lindane, Dieldrin, and p,p'-DDE deposition rates varied between seasons with higher rates typically occurring in the spring. Only Lindane deposition rates have declined over time.

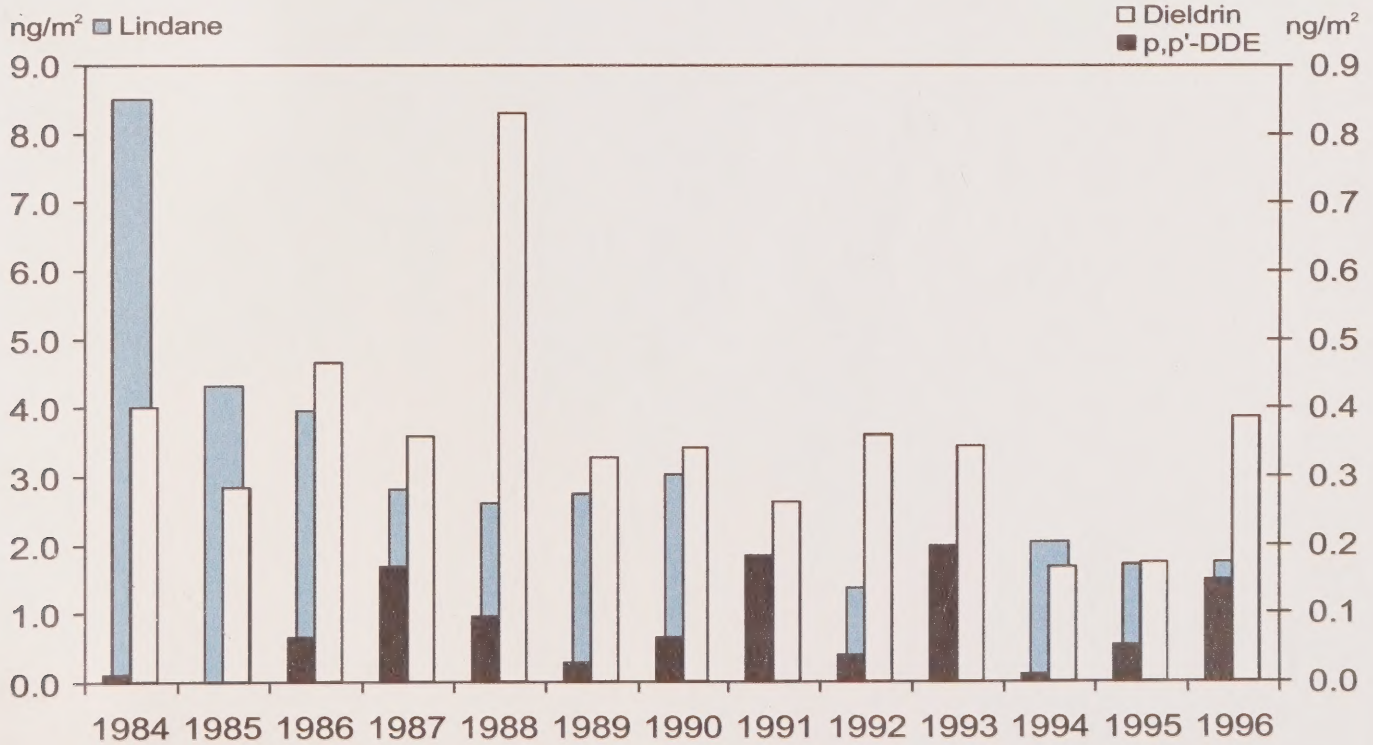
When comparing the open lake data from Lakes Superior, Erie and Ontario, some allowances should be made for analytical improvements over time as well as decreasing concentrations over time as evident from the connecting channels data.

Some contaminants such as Lindane and Dieldrin were observed in all the open lake stations and the connecting channels sites at relatively uniform concentrations. The ubiquitous nature of these two contaminants suggests that the atmosphere was the predominant source. Although, western Lake Erie appeared to have elevated concentrations of both contaminants suggesting a localized source such as contaminated sediments or soils. These two contaminants were observed in the connecting channels predominately (>90%) in the dissolved phase. Dieldrin exceeded water quality criteria throughout the Great Lakes. Lindane did not exceed criteria at any site. Concentrations of both pesticides have decreased by approximately 50% in response to management efforts here and abroad.

The spatial patterns in HCB and OCS concentrations were indicative of localized sources in the St. Clair River and the Niagara River and, for DDT and Mirex, localized sources in the Niagara River. HCB was equally observed in the dissolved phase and suspended sediment phase. OCS and Mirex were only observed in the suspended sediment phase. The suspended sediment phase accounted for the majority of the total DDT concentration. HCB concentrations in the Niagara River have declined by 70% since 1986 although they still exceeded criteria at Niagara-on-the-Lake. Similarly, OCS and Mirex have also declined over time. The average OCS concentration has decreased by 90% in response of process modifications and was below criteria at Niagara-on-the-Lake in 1996/97. Mirex at Niagara-on-the-Lake has decreased by more than 50% in response to the ban in 1977 but still exceeded criteria. Total DDT and p,p'-DDE exceeded criteria in the Niagara River samples.

PCB concentrations have decreased over time at all connecting channel sites. Concentrations at Niagara-on-the-Lake have decreased by more than 70% in response to the 1977 ban. However, whole water concentrations still exceeded criteria.

Benzo(a)pyrene appeared to be localized to the lower lakes as it was infrequently observed in the St. Clair River sites and Wolfe Island site but routinely observed in the two Niagara River sites. All open lake observations were below the detection limit except at one location in western Lake Erie. Benzo(a)pyrene is predominately (>80%) observed in the suspended sediment phase. Unlike the other contaminants, Benzo(a)pyrene appeared to be increasing in concentration in the Niagara River. Whole water concentrations occasionally exceeded criteria at both sites but more frequently downstream.



Yearly Deposition Rates of Lindane, Dieldrin and p,p'-DDE

Suggested Reading:

Merriman, J. 1998. Trace Organic Contaminants in the St. Lawrence River at Wolfe Island. Environment Canada, Ecosystem Health Division Report 98-02/I.

Williams, D.J., K.W. Kuntz, S. L'Italien, and V. Richardson. 1998. Lake Erie Surveillance Program: Spatial and Temporal Trends of Selected Parameters with Emphasis on 1994-95 Results. Environment Canada, Ecosystem Health Division Report 98-05/I.

Williams, D.J., K.W. Kuntz, S. L'Italien, and V. Richardson. 1998. Lake Ontario Surveillance Program: Spatial and Temporal Trends of Selected Parameters with Emphasis on 1992-93 Results. Environment Canada, Ecosystem Health Division Report 98-04/I.

Williams, D.J., M.A.T. Neilson, J. Merriman, S. L'Italien, S. Painter, K.W. Kuntz, and A.H. El-Shaarawi. 2000. The Niagara River Upstream/Downstream Program 1986/87 - 1996/97 Concentrations, Loads, Trends. Environment Canada, Ecosystem Health Division Report 00-01/I.

For Further Information:

See "Our Great Lakes" or the Ontario Green Lane at www.on.ec.gc.ca for more information on the Great Lakes.

For more information on Great Lakes water quality monitoring programs please contact:

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Burlington, Ontario
L7R 4A6
Tel.: (905) 336-4641 Fax.: (905) 336-4609
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This fact sheet will be available on-line in 2000 at the Environment Canada Ontario Green Lane at http://www.on.ec.gc.ca/glimr

Additional information on the Great Lakes Binational Toxics Strategy can be found on the Internet at http://www.epa.gov/bns

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